1.

a. K = U  
½ mv02 = mgH; H = v02/2g

b. K + Wf = U where Wf = –Ffd and Ff = μmg cos θ and d = h/sin θ  
½ mv02 – (μmg cos θ)(h/sin θ) = mgh  
½ mv02 = mgh(μ cot θ + 1)  
h = v02/(2g(μ cot θ + 1)) = H/(μ cot θ + 1)

c. Ktrans + Krot = U where K­rot = ½ I ω2 = ½ (mR2)(v/R)2 = ½ mv02

½ mv02 + ½ mv02 = mgh′  
h′ = v02/g = 2H

d. Rotational energy will not change therefore ½ mv02 = mgh′′ and h′′ = v02/2g = H

2.

a. U = K  
Mgh = ½ Mv2 + ½ Iω2 and ω = v/R  
Mgh = ½ Mv2 + ½ (2/5)MR2(v/R)2 = ½ Mv2 + (1/5)Mv2 = 7Mv2/10  
v2 = 10gh/7

i. Ktrans = ½ Mv2 = (5/7)Mgh

ii. Krot = ½ Iω2 = (2/7)Mgh (or Mgh – Ktrans)

b. i. τ = FfR = Iα = I(a/R)  
FfR = (2/5)MR2(a/R)  
Ff = (2/5)Ma  
ΣF = ma  
Mg sin θ – ­F­f = Ma  
Mg sin θ – (2/5)Ma = Ma  
g sin θ = (7/5) a  
a = (5/7) g sin θ

ii. Ff = (2/5)Ma = (2/5)M(5/7)g sin θ = (2/7)Mg sin θ

c. Ktot = Mgh

d. Greater, the moment of inertia of the hollow sphere is greater and will be moving slower at the bottom of the incline. Since the translational speed is less, the translational KE is taking a smaller share of the same total energy as the solid sphere.

3.

a. i.



ii. x = 33 m

b. i. y = ½ gt2; t = (2y/g)1/2 = 1.75 s

ii. Uinitial = Ubucket + Uprojectile = M(9.8 m/s2)(3 m) + (10 kg)(9.8 m/s2)(3 m) = 29.4M + 294  
iii. Uinitial = Ufinal + K where U­final = Mg(1 m) + (10 kg)g(15 m) = 9.8M + 1470  
Kprojectile = ½ 10vx2 and Kbucket = ½ Mvb2 where vb = vx/6  
putting it all together gives 29.4M + 294 = 9.8M + 1470 + 5vx2 + (M/72)vx2

c. i. x = vxt

d. x(300 kg) = 39.7 m (greater than the experimental value)  
possible reasons include friction at the pivot, air resistance, neglected masses not negligible

4.

a. I = Σmr2 = mL2 + mL2 = 2mL2

b. ΣF = ma; 4mg – T = 4ma  
Στ = Iα; Tr = Iα; T = Iα/r = 4mg – 4ma and α = a/r, solving gives a = 2gr2/(L2 + 2r2)

c. Equal, total energy is conserved

d. Less, the small blocks rise and gain potential energy. The total energy available is still 4mgD, therefore the kinetic energy must be less than in part c.

5.

a. i. mv0 = (3m)vf; vf = v0/3

Kf = ½ (3m)(v0/3)2 = mv02/6

ii. ΔK = Kf – Ki = mv02/6 – ½ mv02 = –mv02/3

b. i. rcm = Σmiri/Σm = m(0) + 2m(l)/(m + 2m) = (2/3)l

ii.



iii. pi = pf  
mv0 = (3m)vf; vf = v0/3

iv. Li = Lf

mv0R sin θ = mv0(l/3) = Iω where I = Σmr2 = m(2l/3)2 + 2m(l/3)2 = (2/3)ml2  
solving yields ω = v0/2l

v. Ki = ½ mv02

Kf = ½ mvf2 + ½ Iω2 = ½ (3m)(v0/3)2 + ½ (2/3)ml2(v0/2l)2 = ¼ mv02

6.

a. K = U  
½ Iω2 = mghcm  
½ (ml2/3)ω2 = mg(l/2) which gives ω = 5 rad/s

b. Ki = Kf  
½ m0v02 = ½ m0v2 + ½ Iω2  
v = 8 m/s

c. L = mvr = (1 kg)(10 m/s)(1.2 m) = 12 kg-m2/s

d. Li = Lf  
12 kg-m2/s = m0(v⊥)l + Iω = m0(v cos θ)l + I ω  
θ = 60º